A Workshop on the Use and Implementation of Remote Sensing-Earth Observation Data to Monitor and Report Landscape Change in and around National Parks

Sponsored by Parks Canada Agency (PCA), the Canada Centre for Remote Sensing (CCRS), and the Canadian Space Agency (CSA) through the Government Related Initiatives Program (GRIP)

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Workshop Report

Parks Canada Parcs Canada

Canada

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Executive Summary

Through the Canada National Parks Act, the Parks Canada Agency (PCA) has been entrusted with the responsibility to protect and present national parks. Under the Act, "*the maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks*". To meet this obligation, PCA has established a reporting framework that includes the production of a State of the Park Report every five years, and a supporting Ecological Integrity Monitoring Program for each park that is to be operational by 2008.

Given the large area encompassed by the existing 42 national parks at the present (equivalent to more than twice the area of New Brunswick, Nova Scotia and Prince Edward Island combined) as well as their geographic distribution across Canada's landmass, effective and efficient monitoring presents considerable challenge. For this reason, PCA is resolved to use satellite-based earth observation (EO) techniques as an integral component of its monitoring framework. To introduce this technology rapidly and effectively, the PCA entered into collaboration with the Canada Centre for Remote Sensing (CCRS) and the University of Ottawa (UO). A joint project was submitted to the Canada Space Agency's (CSA) Government Related Initiatives Program (GRIP), and approved for a four- year period (2004-2008). The project addresses those principal elements of the PCA monitoring framework to which EO will most effectively monitor using EO and includes: stressors (land cover and its changes, fragmentation), ecological processes (productivity and decomposition) and biodiversity (species richness), in addition to communications and outreach.

The motivation behind the workshop described in this report was to evaluate the results achieved by the GRIP project to date in light of the present and anticipated PCA requirements, and to identify changes or additional work that needs to be carried out for the EO- based products to more completely meet PCA needs in 2008 and beyond. The workshop discussions were structured according to the above GRIP project themes. Each topic or Work Package (WP, Figure 1) was introduced by a PCA representative who explained the requirements and other relevant considerations. Next, a GRIP study leader described methods and products developed to date. In parallel breakout groups, the subsequent discussion of the GRIP results was guided by specific questions that related the GRIP results to the PCA needs envisioned for 2008 and beyond. Each group was also requested to identify actions that would improve the utility of the GRIP products to meet PCA needs.

Based on the results of the detailed discussions, it is evident that the GRIP project is on track to meeting its stated objectives, and that the products being developed match well with PCA needs. So far the land cover, land cover change, fragmentation, and productivity/ decomposition products are most developed and are well aligned with PCA reporting needs. Progress in species richness modeling is subject to access to more complete data sets that will follow this workshop. A number of suggestions were made that will enhance the quality or usefulness of the results generated by the GRIP project, and many linkages were established that will help incorporate the knowledge and contributions of the PCA field staff into the EO-based products. Follow- up actions and responsible individuals were also identified in all the above areas. The most important overarching issue is systematic transfer of the GRIP- developed methods into an

operational system to support PCA national monitoring, and actions were initiated to accomplish this successfully and in a timely way.

Following the detailed reviews of the GRIP results to date and the extensive discussions of their strengths, potential improvements and needed changes, it can be concluded that the objectives of the workshop were fully met. The broad representation (geographically and ecologically) of PCA staff from across the NP network, as well as PCA monitoring experts, lends confidence that the identified actions are closely aligned with present and future PCA national monitoring program needs. In the words of one PCA workshop participant:

"Remote sensing lets us 'see' the land base at a very reasonable cost. Value for remote sensing is very high. Economics are very strong to be pursued"
Darrel Zell, Banff National Park

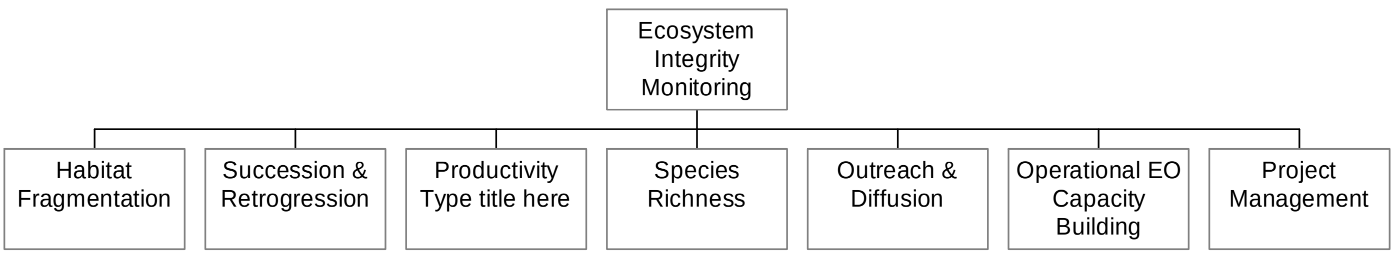

Figure 1 Project Work Breakdown Structure

Introduction and objectives

Parks Canada Agency is in the process of developing a comprehensive and sustainable ecological integrity (EI) monitoring systems in all 42 national parks – a system that is to be in place by April 2008. EI monitoring is being established to meet park needs for a comprehensive assessment of a park's EI every 5 years in a State of the Park report, and to meet agency needs to produce a system-wide State of Protected Heritage Areas report every 2 years. Remotely sensed Earth Observation (EO) data are expected to provide an important component of the information required for reporting on potential changes in the EI of national parks.

Changes in land use and other human related factors in the areas surrounding national parks can have significant implications for meeting conservation objectives within park boundaries. As examples, wide-ranging park ungulates and carnivores often require habitat elements outside park boundaries; adjacent agricultural or industrial use can pollute or otherwise affect park ecosystems; and roads leading up to park boundaries can provide a conduit for alien plant invasions and unauthorized human activities. Consequently, an important component of monitoring and reporting long-term changes in park EI is the capability to track changes in the lands that surround protected areas.

Parks Canada Agency (PCA) has been working with the Canada Centre for Remote Sensing (CCRS) and the University of Ottawa (UO) to develop EO- based tools for monitoring and reporting on landscape change in and around national parks. This work has been carried out under funding provided by the Canadian Space Agency (CSA) through its Government-Related Initiatives Program (GRIP). The project was initiated in September 2004 and will continue until April 2008. The motivation for the GRIP project was to develop, demonstrate and implement operational EO data processing and analysis tools for assessing and reporting on landscape change in and around national parks. Carried out by a joint CCRS-PCA-UO team, the project is focusing on 7 model parks (Table 1) that represent a range of ecosystems and landscape stressors across the system of Canada's national parks.

The methods and targets for using and understanding EO data to assess landscape change are likely to vary depending on park size and setting. The ecological effects of changes in land cover and land use in areas surrounding large wilderness parks in remote settings are very different and have different effects than land changes surrounding smaller parks located in industrial, agricultural and rural-residential landscapes. In general, long-term monitoring to detect and record landscape change in and around protected areas requires reliable and repeatable information that can be provided at a reasonable cost and in a timely manner to meet reporting requirements. The GRIP project focuses on providing tools to monitor and report on four aspects of landscape-level change: changes in vegetation cover/disturbance, landscape pattern, terrestrial ecosystem productivity, and biodiversity.

At the workshop, representatives of the 7 project model parks and other PCA specialists assembled to review results of the GRIP project to date and to exchange information on both the delivery products and the operational needs of park monitoring practitioners, in order to chart a way forward to establishing effective and operational EI monitoring of landscape change in all of Canada's national parks. The specific objectives of the workshop were:

1. To review the progress of the GRIP project in the context of PCA reporting and park management needs for information, and;
2. To identify actions to be taken, in the GRIP project and otherwise, to ensure that PCA has the information required to maximize the use of EO data for park EI monitoring and reporting.

Table 1. The list of national parks by bioregion (GRIP pilot parks are highlighted).

Atlantic-Quebec Bioregion	Great Lakes Bioregion	Interior Plains Bioregion	Southern Mountains Bioregion	Pacific Coastal Bioregion	Northern Mountains Arctic Bioregion
La Mauricie	St. Lawrence Islands	Grasslands	Jasper	Gwaii Haanas	Nahanni
Mingan	Pt. Pelee	Riding Mountain	Banff	Pacific Rim	Tuktut Nogait
Forillon	Bruce Peninsula	Prince Albert	Yoho	Gulf Islands	Kluane
Kouchibouguac	Georgian Bay Islands	Elk Island	Kootenay		Vuntut
Fundy	Pukaskwa	Wood Buffalo	Revelstoke		Auyittuug
Prince Edward Island			Glacier		Sirmilik
Cape Breton Highlands			Waterton Lakes		Ivvavik
Kejimkujik					Aulavik
Terra Nova					Wapusk
Gros Morne					Quttinirpaaq
					Ukkusiksalik
					Torngat Mtns.

2. Approach

The workshop was organized according to EI monitoring and reporting themes identified in the PCA Monitoring Framework. These were also the themes addressed in the planning and design of the GRIP project, making them a logical choice for organizing workshop presentations and discussion. The following topics were dealt with:

Topic 1: Ecosystem Processes - Succession/ Retrogression;
Topic 2: Stressors - Habitat fragmentation;
Topic 3: Ecosystem Processes - Productivity and Decomposition;
Topic 4: Biodiversity – Species Richness;
Topic 5: Other EO requirements of the PCA;
Topic 6: Outreach.

Except for #5, the topics coincide with work packages of the GRIP project. Topic 5 was added because of its strategic importance for the PCA.

For each Topic #1 through #4, an introductory presentation was given by a PCA specialist that addressed the role and importance of the topic for park monitoring and management, how this information is presently collected (or not collected), how the GRIP project can improve this situation, and it added other relevant observations and suggestions for discussion or consideration. For the last two topics, the introductory presentation dealt with the following questions:

- What are the overall PCA requirements?
- What are the weaknesses/ opportunities given the current situation?
- What are the possibilities for taking advantage of the knowledge, materials etc. available so far (especially in the GRIP project)?
- What are remaining unmet needs and how they might be best addressed (be as specific as possible)?
- Other observations, suggestions for discussion or consideration.

After the introductory PCA presentation, GRIP project progress was reported by a leader of the work package. These presentations were then followed by a discussion in one to three parallel breakout groups, depending on the topic. Each group addressed the same set of questions (refer to Appendix 5.5).

The presentations of GRIP results focused on work completed on a case study at La Mauricie NP (especially for Topics 1-3), how these approaches can be applied to all 7 model parks, and eventually to all 42 national parks. The discussion dealt mainly with EO- derived products, the surface (*in situ*) measurements that will be required to support satellite observations, and the longer- term issues related to the sustained use of EO by the PCA.

To further enhance information exchange and the understanding of park conditions, participants also brought posters and other materials for display that were also presented at a plenary session (documents accessible at ftp.pcan.ca/home/pca/National Office/MONITORING).

This report summarizes the discussions and main results of the workshop. The comments and contributions made in each breakout group were recorded, and subsequently grouped according to the issue addressed. The draft workshop report was circulated to workshop attendees, and their comments and revisions were incorporated in the final version. The actions recorded in each section and summarized in Appendix 5.1 were reviewed and approved at the last plenary session. Thus, the report represents a consensus of the workshop participants who include representatives of the GRIP team, the PCA EI Monitoring and Reporting Program, a number of national parks, PCA regional centres, and other parts of the PCA.

3. Results

3.1 Topic 1: Succession and Retrogression

The PCA perspective on this topic was introduced by McLennan (2006, Appendix 5.4).

3.1.1 GRIP project results to date

Olthof (2006) presented methods and products developed so far in the GRIP project. The main product is a time series of land cover maps for La Mauricie NP representing 1985, 1990, 1995, 2000, and 2005. The five land cover maps were prepared from Landsat Thematic Mapper data after applying cloud masking, haze removal, classification of the 2005 data, and signature extension of the classes to the previous time periods. All the algorithms were or can be automated, except for the classification procedure in which the labeling of spectral clusters requires expert input. The hierarchical classification legend was based on the standard adopted by the US Federal Geographic Data Committee (FGDC) which, after adjustment for northern ecosystems, consists of 45 land cover classes. The accuracy of the 2005 product was tested with 2005 field data (overall accuracy on a pixel basis 72.1%), and with an existing forest cover map (Carte Ecoforestiere). Carte Ecoforestiere, consisting of 12 classes, was evaluated in an independent study and was found to have variable accuracy. Three of the classes had better accuracy (94% for conifers, 60% for mixed, 29% for deciduous stands); for these three classes, the agreement between Carte Ecoforestiere and the GRIP maps was 70.3% on a per-pixel basis.

Olthof (2006) also described land cover change products derived from three sources: the above series of land cover maps, vegetation indices computed from the corrected satellite data, and decision rules developed to guide the labeling procedure; the latter were based on likely transitions among land cover types, taking into account ecological and land use factors. The land cover change product accuracy was 77.8% based on 2005 field data. The change detection and labeling algorithms were also automated, permitting rapid generation of the change products once land cover maps are available.

Further details on the above products were provided by Olthof (2006).

3.1.2 Discussion

<u>Product needs.</u>

For each national park (NP), PCA requires information on the distribution and composition of forest and other cover types, their changes over time, and the ecological significance of these changes. Ideally, such information would be available by species, at high (~5-10m) resolution, at least once every 5 years, for both park and the Greater Park Ecosystem (GPE), and in a guaranteed manner in the future. PCA also requires information on vegetation health monitored at shorter time intervals over the growing season (days to weeks); coarser spatial resolution products (250m-1000m) are sufficient in this case. Disturbance and regeneration are important change types. Of special interest are large-scale disturbances in and around parks by type (e.g., land use vs. natural change; fire vs. insects vs. storm damage).

Since PCA also requires that the above information be available at a reasonable cost and updated annually for about 10 parks (thus meeting the goal of reporting on all parks once every five years), practical compromises must be made. Landsat Thematic Mapper (TM) images (resolution of 30m) are used in the GRIP project due to their comparatively low cost and relatively rich information content. This data source satisfies the requirements for the mapping of basic cover types, revisit frequency, and change detection capability (refer to Olthof (2006, Appendix 5.4). Taking the above factors into consideration, workshop participants discussed other types of desirable information and the ways in which these might be obtained. The following issues and points were raised.

Classification legend:

The ecological and management questions to be addressed using the land cover products will vary by park. Therefore, ideally park- specific products are needed. On the other hand, consistent products are required at the national level. To satisfy both needs, possible approaches might be:

- Prepare products to the same legend for all parks, and develop park- specific look- up tables for characterizing individual land cover categories (e.g., by dominant species). So far, the FGDC legend with 45 classes has been used because of their applicability everywhere in Canada. At the start of the GRIP project, the legend has been vetted with PCA staff.
- Prepare an intermediate classification product, and let park staff label the spectral clusters thus identified.
- Increase the number of levels in the FGDC hierarchical classification scheme to suit park needs, or use another scheme on a park- specific basis.
- Prepare park- specific land cover products for special uses in addition to the common products, provided that the thematic resolution of such products meets park needs (e.g., distribution of beech, maple and birch species for studies of bear movements in La Mauricie NP).

Current GRIP land cover product:

The deficiencies of the Landsat- derived products so far include:

- Lack of information on wetland succession which may be ecologically significant. This information may require the use of other satellite sensors (e.g., SAR).
- Seral stage (structure) is required in the taiga/tundra zone.
- The needs of marine portions of the NPs and the National Marine Protected Areas (NMPA) have not been given careful consideration so far, but will be important in other pilot parks.
- The spatial resolution (~30m) does not encompass all ecological phenomena of potential interest. In these cases, the land cover products can be used as an early warning marker, in conjunction with fieldwork or other tools to assess the significance and consequence of the land cover changes.
- Forest stand age information is desirable, but not always provided satisfactorily through Landsat data. Minimum classification would include young, immature and mature classes. Many parks have fire history data to derive a baseline stand age distribution that could be combined with the satellite- derived product. Once available, Landsat is fully capable of updating stand age through disturbance monitoring.
- Landsat exists today but may not remain operating until the next satellite is launched. However, other sensors may be used to bridge the gap, and the GRIP methodologies developed so far facilitate cross-walk between sensors.

Product accuracy issues:

- There are different accuracy requirements depending on what is to be monitored. No single accuracy could be identified, but the need is for methods that have 80% power to detect change at the landscape level. Ideally, the products should facilitate the detection of thresholds as well as quantification of the rate of change. For disturbances, the change in the park will typically be much slower than in the GPE; this may not be the case of other effects (e.g., climate change).
- Error assessment is definitely needed for any products that are created. The accuracy should be field-checked with enough observations so the accuracy figures will apply at the landscape ecosystem level. Field accuracy assessment requires about 40 validation points per class. Higher resolution satellite or airborne data could also be used to quantify product accuracies. It should be remembered that PCA plans to assess and report ecological integrity at the park (and GPE) level, so the accuracy specification needs to be relevant at this level.
- Product accuracy has an important practical dimension, as increasing product accuracy beyond a desired limit may be exceedingly costly and/or labour intensive. The land cover product for La Mauricie (Olthof, 2006) has an accuracy of about 72% at single pixel level; this should translate into a substantially higher accuracy at the landscape level.
- Taking practicalities into consideration, the PCA requirement is for the "most precise data product with the least amount of error that is affordable and has appropriate metadata".

Disturbance issues:

- In relation to fire disturbances, PCA staff needs information on fire severity and fuel type for fire behaviour modeling.
- Monitoring information is needed on natural disturbances (pests, mountain pine beetle red attack early warning, blowdowns, fire).
- It is often difficult to get disturbance data outside of the NPs (areas held by industry, etc.).

Other considerations:

- There is a need for an archive where all the GRIP project data (and data products) are stored and made available to those who need them.
- In considering PCA data requirements, the broader spatial context needs to be taken into account (for example, upwind sources of air pollution).

Potential options to improve the land cover product:

- Use other ancillary data (digital elevation models, *in situ* data, soil maps, ecological land classification maps, provincial land cover maps (to delineate agricultural land), stand age maps or stand age point data);
- Create better or different decision rules.
- Consider use of object- based image classification techniques.
- Test crosswalk between sensors that may potentially be used (SPOT HRV, IRS) and quantify added noise for various park ecosystems.

3.1.3 Actions

The following actions were agreed to:

a) Follow up accuracy assessment (it is needed at the reporting resolution/ landscape level, for cover types within the landscape, through enough field checks, once). No one minimum accuracy specified, but would like 80% 'power' to detect change at the ecosystem level, every 5 years.
Responsible: Olthof, Poitevin *Report Due: 1 April, 2006*

b) Involve park staff in labeling (including species level) and *in situ* accuracy assessment, and consider other ways of improving the suitability of the land cover product (e.g., use of the FGDC legend, its revisions, or of another legend; combination of nationally applicable and park-specific; better decision rules; use of EOSD products; value of object - based classification, etc.).
Responsible: Olthof *Report Due: 31 August, 2006*

c) Describe the post-GRIP delivery model. Must be able to complete approximately 10 parks per year.
Responsible: McLennan, Fraser *Report Due: 30 June, 2006*

d) Assess use of other data types (higher spatial resolution and higher temporal resolution) to better meet PCA needs; test crosswalk to SPOT/ other primary data source for robustness.
Responsible: Fraser *Report Due: 31 December, 2006*

e) Pursue options for improving Landsat products and adding other useful products, such as: integration of ancillary data (DEM, provincial data, ecological land classification maps, soil data, fire history data, stand age maps, etc.); use radar images for wetland succession mapping; use fuel type maps for fire danger; use EO proxies of vegetation health (e.g., vegetation indices), seral stage (structure) for taiga, tundra.
Responsible: Olthof *Report Due: as appropriate*

3.2 Topic 2: Fragmentation

The PCA perspective on this topic was introduced by P. Zorn.

3.2.1 GRIP project results to date

Pouliot (2006, Appendix 5.4) described results of an investigation designed to evaluate EO-based measures for characterizing landscape spatial properties through time. Specific interest was in the identification of a) representative and stable landscape fragmentation metrics (FM), b) scaling properties or scaling approaches to provide FM consistency across scales, and c) the means of evaluating FM values through thresholds or guidelines. The following metrics had been most often recommended in the literature: area of core area, patch density, mean patch size, edge density, proximity/ isolation (mean nearest neighbor distance and mean proximity index), shape (perimeter to area ratio, perimeter area fractal dimension, shape index), and contagion (percentage of like adjacencies, adjacency index, clumpy, division, split). In the GRIP project, a large database of Landsat TM- based classifications across Canada (including several NPs) was created and analyzed using the Fragstats software package. The GRIP team studied the behaviour of different fragmentation measures in various landscapes, their response at various spatial scales, their behaviour in relation to the expected trajectory of change based on field data and other sources, their relation to ecological significance of the observed fragmentation, and the feasibility of identifying thresholds of significant changes that might be used in reporting and in formulating management response.

Based on the results to date, the GRIP team concluded that:

- The existing fragmentation metrics are highly landscape- dependent with strong scale sensitivity and limited direct metric scaling potential, and many also exhibit non-linear behaviour;
- The signal- to- noise analysis procedure developed in the project may be useful for providing additional information for FM selection. However, further evaluation is required;
- Comparison of FM values against thresholds or guidelines determined from the set of “highly fragmented” landscapes appears to provide a useful approach for FM evaluation.

They also identified several questions to be pursued through further research.

3.2.2 Discussion

<u>PCA requirements:</u>

- PCA requires information on landscape fragmentation for multiple purposes: an assessment and reporting of the impact of fragmentation on EI; as a measure of anthropogenic stress; for monitoring restoration after natural fire, prescribed burns, or similar disturbances; to communicate with the public or partners (fragmentation products are readily understood by non-specialists, “time sequence of roads expansion is the most influential piece of communication data”), and for other reasons.

- Ideally, PCA requires fragmentation products that are nationally consistent, are available at various spatial resolutions (<10m to 1000m) for both NP and the GPE, apply equally at all scales from landscape to NPs in all six bioregions, and are sensitive to various types of land cover changes. The need for different resolutions and spatial extent are determined by the monitoring question; with multiple questions, fragmentation information will be needed at a range of spatial scales.

- Frequency: It was agreed that a Landsat TM- based fragmentation product (or equivalent) should be available every five years as the minimum standard, and a product based on 250m-1000m data (MODIS, AVHRR, SPOT VEGETATION) every year for large-scale phenomena (large fires, large pest outbreaks).

- Spatial extent: It may be desirable to report outputs separately for the park and its GPE. The same metric should be used for both, but possibly at different scales.

- Maximum spatial resolution: The fragmentation products need to include forest roads which initiate the chain of landscape fragmentation. This would require the use of higher resolution (<10m) satellite data, GIA road layers, and possibly additional algorithms to be developed or tested. In this case the update frequency, data continuity and costs would have to be examined.

- Additional data: Seismic lines and roads are required. Road configuration and traffic density can be more important than the total road length. Highway location and traffic density may have an effect on the species population level. Fuel modification around towns (designed to prevent fire spread) may have strong effect on connectivity. Road abundance also relates to cutting and hunting/ trapping.

- As an option for fragmentation monitoring and reporting, it was suggested:
    - Every five years for Landsat TM (or equivalent, ~30m) is the minimum standard;
    - Every year with MODIS, AVHRR (~250m - 1000m) for large fires, large pest outbreaks;
    - Might consider yearly Landsat TM product for parks that are in the "red" phase of the indicator.

<u>Interpretation of fragmentation products:</u>

- Although many different fragmentation products can be readily calculated from sequential land cover maps as demonstrated by Pouliot (2006, Appendix 5.4), their interpretation will most likely be park- and possibly also disturbance type- specific. Therefore, the workshop consensus was on the development of a small set of fragmentation products that would preferably be produced using the same methodology for all NPs, would be effective at a range of spatial resolutions, and would be interpreted or otherwise used at the NP level by ecologically knowledgeable PCA staff. The necessity of the last step stems from the fact that the process context drives the interpretation of the fragmentation metrics. The focus can be on a fragmentation of a community type (which includes a range of species); and on landscape rather than habitat fragmentation, thus providing a more generalized information applicable to various species.

- The interpretation may concern uses such as:
    - Differentiation between disturbances: total disturbance, and human vs. natural (various types) categories;
    - Forecasting fragmentation level resulting from prescribed burn programs; serving as a management tool by assessing fragmentation that will result from burn;
    - Monitoring changes in patch size distribution (e.g., in Arctic parks the size of patches is important under climate change);
    - Changes in the regeneration and habitat due to fragmentation; for example, a temperature of 50^{o} C has been measured in the centre of large clearcuts in northern Saskatchewan;
    - Local effects of habitat fragmentation (e.g., in Waterton NP the construction of a sidewalk nearly rendered extinct a small salamander that could not climb the sidewalk built across its migration route);
    - Monitoring indices and defining thresholds: Is the park becoming more or less fragmented? Historical level of fragmentation serves as a baseline. Thresholds are species- specific, and so must be the FM interpretation. The relation between fragmentation and species abundance tends be linear;

- Fragmentation indices need to be linked to EI by parks, and related to observed changes in species or vegetation abundance (both within NPs and the GPEs);
- Management: Parks are not managed for specific species, but must maintain desired level of ecosystem integrity and fragmentation. However, fragmentation must also consider species at risk and specific habitat requirements for key species. Roads, forest clearcuts, and habitat conversion (land use or land cover change impact) are most important;
- Monitoring and assessing anthropogenic stress (exotic species, poaching, hunting, roads, seismic lines, forestry and other development). For marine parks, need information on boat roads, shoreline modifications, and other drivers leading to the various stressors.

<u>Fragmentation metrics:</u>

- The stable metrics identified by Pouliot (2006) were considered a good candidate FM subset, subject to further assessment. The set consists of area measures, density measures, edge measures, and contagion measures. Also, other specific metrics could be used for individual parks in special cases. Further methodology developments are needed to:
    - Extend the analysis to other cover types and their combinations (only forest- non-forest tested so far), and include other NPs in sample;
    - Based on the findings from the pilot parks, set standards for other parks and develop guidelines for use of the fragmentation products in all NPs.

- It was noted that the value of fragmentation indices as an EI indicator for park management has not been established conclusively. Currently, they are related to individual species in some parks. Also, management response is not straightforward. For example, fragmentation has been identified as one of major stressors in the Jasper/ Banff NP and many southern parks, but the PCA is currently unable to do anything about it.

3.2.3 Actions

The following actions were agreed to:

a) Finalize the selection of a parsimonious set of fragmentation metrics applicable nationally, at different resolutions/spatial extents, and to different sensors. The presented set is considered a good start.
Responsible: Pouliot, Zorn *Report Due: 30 June, 2006*

b) Explore if different products (resolution/coverage) are needed within NP and the GPE. Explore if additional FMs are needed for individual parks. Consider if further work needs to be done by the GRIP project to improve understanding of FM behaviour.
Responsible: Pouliot/Zorn *Report Due: 30 June, 2006*

c) Produce fragmentation products for the remaining pilot parks (prioritize as appropriate).
Responsible: Clouston *Report Due: January 31, 2007*

d) Subject to resources availability, follow up improvements to the products:
    - Incorporate roads into the FM products;

- Incorporate landscape pattern;
- Investigate the use of higher resolution satellite data sources (radar, optical);
- Investigate other data sources with different resolution/ extent characteristics (particularly medium resolution satellite data);
- Test crosswalk to other sensors; expand the sample against which to test the FM robustness; explore options for extending time series to the past.
  Responsible: Pouliot *Report Due: March 31, 2006*

e) Compile guidelines for the use of FM products across all national parks.
Responsible: McLennan *Report Due: March 31, 2008*

f) Interpret FM products (in combination with ancillary data) in pilot parks for local issues. Explore use of fragmentation products for identifying critical habitats (species at risk).
Responsible: McLennan - Bioregional ecologists *Report Due: Dec 31, 2007*

g) Pursue identification of ecologically based thresholds for fragmentation in the GPE (to facilitate meaningful discussion with partners about changing land use practices).
Responsible: McLennan - Bioregional ecologist *Report Due: Dec 31, 2007*

h) Every park will need to provide/define its Greater Park Ecosystem.
Responsible: McLennan - Bioregional ecologist *Report Due: As appropriate*

i) Develop a protocol for dealing with changes in technology (i.e., satellite sensors or *in situ* instruments).
Responsible: McLennan, Fraser *Report Due: June 30, 2006*

3.3 Topic 3: Productivity and Decomposition

The PCA perspective on this topic was introduced by Naughten (2006, Appendix 5.4).

3.3.1 GRIP project results to date

The GRIP team presented results of studies designed to evaluate the use of an ecosystem model for quantifying and reporting on ecosystem functioning (Wang, 2006, Appendix 5.4). The EALCO model (Ecological Assimilation of Land and Climate Observations) is a process- based, point model that is designed to mimic the functioning of a soil-plant-atmosphere system. It can accept EO- derived land cover and leaf area index products to produce maps of net ecosystem productivity and its components (net primary productivity (NPP), decomposition,..) or, if phenological information is not available from satellite data, it will 'grow the plant' based on the remaining inputs (meteorological data, soil data, vegetation characteristics,..). The model runs at 30 minutes time steps. It has been successfully validated for forest stands (aspen and black spruce). It has previously been applied to produce NPP and other components of the carbon budget for La Mauricie NP and its GPE over 40 years (Wang, 2006), and for all Canada over a similar period. In these cases, the model assimilated 30m- or 1000m- resolution satellite-derived products and used gridded versions of climate and soil input data.

3.3.2 Discussion

Product requirements:

- Productivity and decomposition are key ecosystem function measures selected for PCA EI reporting. Both vary greatly over a wide range of spatial and temporal scales, and are difficult to measure well - even at the site level where multiple sampling of several carbon pools or a sophisticated flux tower monitoring instrumentation are needed. Therefore, while the PCA plans to include *in situ* measurements of decomposition into its field monitoring program, it has a need for an approach usable over larger areas (NPs and the GPEs). The workshop discussion therefore concentrated on understanding and assessing the value of the EALCO model results.

- PCA needs productivity and decomposition information at the landscape level, over the NP and the GPE, with an accuracy reflecting within-landscape variability. This could be met by either running the model at a high spatial resolution (~30m), or by driving it with 250m-1000m EO products that are appropriately scaled for the variability in topographic, hydrologic and soil properties. The advantage of using the lower resolution satellite data is that the phenological factors (including stressors such as defoliation) would be accounted for through EO- derived leaf area index input products. Park size will also be a factor in selecting appropriate spatial resolution. A continuous modeling, yielding mean and variance per year over 5-year periods (or a moving average) would provide the information needed. The outputs should be available in maps, tables, and other formats (e.g., animation for PCA outreach).

Suitability of EALCO products:

There was a general consensus among PCA staff that EALCO outputs would meet the PCA reporting needs. Specific comments were raised regarding some issues.

- A good precision of the model outputs is more important than absolute accuracy, so that trends may be detected. Changes in the model would therefore require that the time series be recomputed, as is standard practice with similar modeling applications;
- The model may not be sensitive to stressors that are not quantified through input data (meteorological, EO- based, or soil). Therefore, there is a need for an inventory of stressors/disturbances not quantified reliably through remote sensing;
- It is important to ensure the model is sensitive to stressors and their ‘tipping points’ beyond which ecosystems function may change abruptly. Most of the knowledge about the state of stressors comes from measures of defoliation, land use, proximity, and similar stressors;
- The model could be used to project the impacts of climate change on NPs under various climate change scenarios. However, NPP may be an integrated measure of stressors and thus identification of the climate change signal may be a challenge;
- The EALCO model performance will be affected by limitations in meteorological observations (especially their very low density in the North) and by the knowledge of plant physiological constants. However, it would be substantially easier to extend its use to other NPs than for semi- empirical or empirical models;
- Results delivery should also include model inputs due to their importance for understanding the model outputs;

- More variables (species, insect infestations) could be included in the model, or the model outputs could be used as inputs into other stand- alone models;
- An advantage of a model over satellite observations of phenology alone (like vegetation index) is that the model provides substantially better information on ecosystem functioning at various levels (e.g., EALCO accounts for microbial activity in its nutrient cycle). For this purpose, a process- based model is also superior to accounting- type approaches used for estimating forest biomass growth;
- How well is the model packaged, and how easily it is used by others?

<u>*In situ* measurements:</u>
The EALCO model performance would be enhanced by using actual field measurements. The most important observations are:

- Seasonal leaf phenology (start to leaf, full leaf out, maximum LAI, date of senescence) of selected deciduous stands, ongoing;
- *In situ* initial conditions: soil carbon (kg/m^2); soil physical properties (average texture); relative species composition, shrubs percent cover, plant species composition;
- Weather data: shortwave (and longwave) radiation, daily max-min temperature, precipitation (daily), humidity, wind speed, atmospheric pressure;
- Leaf Area Index (LAI) using digital camera (once per NP).

3.3.3 Actions

The following actions were agreed to:

a) Identify *in situ* observations (minimum set) that are required to ensure ongoing confidence in model outputs
Responsible: Wang, McLennan *Report Due: March 31, 2007*

b) Proceed with model improvements:
- Increase resolution to the species level (would be highly desirable);
- Validate age- productivity simulations;

Responsible: Wang *Report Due: March 31, 2007*

c) Ecosystem productivity is affected by factors currently not represented in the model (e.g. fire, insects). Determine if these should be accommodated by increasing model complexity, or by using EALCO model output as input into other models.
Responsible: Wang *Report Due: As appropriate*

d) Identify and evaluate options for generating NPP and decomposition products at the frequency and timeliness appropriate for national reporting (~10 parks per year), propose a realistic and cost- effective scenario to PCA with product types, formats, schedules and costs.
Responsible: McLennan, Wang *Report Due: June 30, 2006*

e) Define accuracy requirements for outputs.
Responsible: McLennan-Bioregional ecologists *Report Due: December 31, 2006*

f) Examine the feasibility and implications of collecting and providing measures of –

- Seasonal leaf phenology (most important are starting date to leaf, maximum LAI (via digital camera); also if feasible full leaf out, date of senescence), insect defoliation data;
- *In situ* initial conditions – soil carbon (kg/m^2); soil physical properties; species composition;
- Climate data: shortwave (and longwave if feasible) radiation, daily maximum and minimum temperature, daily precipitation, relative humidity, wind speed, atmospheric pressure.

  Responsible: McLennan *Report Due: June 30, 2006*

3.4 Topic 4: Species Richness

The PCA perspective on this topic was introduced by S. McCanny.

3.4.1 GRIP project results to date

The GRIP team presented results of the work so far (Kerr and Desrochers, 2006, Appendix 5.4). The approach uses several geospatial data types to model species distributions within and around NPs. Genetic algorithms have been used so far, but other alternatives are available (e.g., habitat modeling). Once the algorithms are 'trained' to associate combinations of environmental variables with the occurrence of a species, they can identify other similar locations where the species might occur even though no observations were made at these locations.

Because this approach uses all EO- derived GRIP products as well as data sets of species occurrence which are generally not publicized, the products completed so far represent work in progress. For the Nahanni NP, products for bald eagle, osprey and kestrel have been prepared for field evaluation. Some work has also been done for black bear distribution in La Mauricie NP. Further progress requires completion of the EO products and availability of species occurrence data sets in the NPs.

3.4.2 Discussion

<u>PCA requirements:</u>

- PCA needs various types of biodiversity information, many not addressed at the workshop. The discussion focused on the need for 'habitat- type' spatial products obtained from gridded environmental data sets and species occurrence data;

- PCA has the need for modeling tools and derived products such as those developed in the GRIP project for the following reasons:
  - to identify new areas of potential habitat, which may offset losses from other stressors;
  - to help understand species/habitat relations;
  - to inform where monitoring efforts are most needed;
  - to have capacity for prediction, for example allowing an evaluation of the impacts of different climate change scenarios;
  - to identify the potential outer boundaries of a species habitat; to identify potential habitats for isolated populations;
  - to help design and set the standards for monitoring (e.g., define the extent and properties of the area that a species is using);

    - to track changes in habitat suitability through time;
    - to study spatial dynamics of habitat use;
    - as a hypothesis about species distribution to address habitat issues in the GPE; and for other purposes;

- Depending on the species of interest, there are many scales at which modeling can be carried out. Park staff with modeling experience have found that applications are best carried out at varying resolutions, ranging from 1000 m to 30 m and higher. From a NP perspective, the modeling products should be relevant to as many focal species as possible. Accuracy requirements could not be specified with confidence. Park staff needs to define accuracy requirements for outputs of such modeling, and procedures for evaluating the accuracy of the output products;

<u>Current GRIP products:</u>

- The GRIP products presented at the meeting (Kerr, 2006, Appendix 5.4) were considered to be relevant to PCA needs. They consisted of modeling products for the annual and seasonal distribution of black bears within La Mauricie NP, and a series of distribution models for birds for Nahanni NP and GPE (bald eagle, kestrel, osprey, loon). First impressions by the park representatives (Nahanni, Pacific Rim) were positive;

- The model- based products represent potential species distributions rather than actual ones which are ultimately of interest. While the latter may in principle be obtained through direct observations, such approach is costly and may realistically be implemented only for a few focal species. There is a need for considering a hybrid observation-modeling approach, in which direct observations would be combined with model outputs to track the changes in species richness most effectively given available resources.

- The basic modeling products should use GRIP EO outputs (land cover, productivity, fragmentation, other EO products), but ancillary geospatial information characterizing the environment is also needed (climate, digital elevation models, human use if it affects species distribution, etc.). The incorporation of temporal environmental information may also be important and where change is detected, it should be included in the model. The modeling efforts need to be park- and species- specific because different parks have different focal species. In building and testing the models, it is important to include the impact of stressors (e.g., clearcutting);

- Availability of adequate observations on species presence is a key requirement for the development of useful modeling products. Ideally, the observations should encompass the entire variability of species habitats with their environmental factors, although some extrapolation beyond the sampled environmental space may be feasible. The existing occurrence data were typically obtained for individual species. They may be available from park wardens, from visitors (need to be validated prior to use), from wildlife observation cards, from the Nature Serve database, and through other sources. At least 35 site observations are needed for model testing. The existing data are often a result of opportunistic sampling; a more rigorous approach and standardized protocol development are required;

- The GRIP (and similar) modeling tools and products represent a new approach within the PCA, and the staff need to develop greater understanding of the capabilities and limitations.

3.4.3 Actions

The following actions were agreed to for this work package:

a) Complete/ revise and validate products generated to date, in collaboration with park staff.
Responsible: Kerr, McCanny *Report Due: June 30, 2006*

b) Produce products for other pilot parks, subject to available data.
Responsible: Kerr *Report Due: March 31, 2007*

c) Prepare draft protocol for *in situ* observations required for these types of models (sampling methodology,) and distribute to park staff.
Responsible: Kerr *Report Due: June 30, 2006*

d) Consider incorporating fragmentation products.
Responsible: Kerr, Zorn *Report Due: Mach 31, 2007*

e) Describe the business model for generating and using products for other parks (post-GRIP), and further examine potential use of the products for reporting.
Responsible: McLennan, Kerr *Report Due: June 30, 2006*

f) Work with park staff in the pilot parks on the interpretation and use of the products.
Responsible: Kerr, McLennan-bioregional ecologists Report Due: ongoing

g) Provide species observations data sets to the GRIP project for the pilot parks.
Responsible: Kerr, Lee, McCarthy, Peterson *Report Due: March 31, 2006*

h) Provide element occurrence database for all pilot parks to Kerr.
i) Responsible: McCanny *Report Due: March 31, 2006*

j) Define accuracy requirements for outputs.
Responsible: McLennan-Bioregional ecologists *Report Due: December 31, 2006*

3.5 Topic 5: Other EO Needs of the PCA

The PCA perspective on this topic was introduced by J. Quirouette.

3.5.1 PCA requirements

This topic was included in the workshop because of the overall PCA need to consider more effective use of EO data and methods in meeting its mandate, given that the scope of the GRIP project is limited to the four above topics. A presentation on future work planned by CCRS was provided as background information (Fraser, 2006, Appendix 5.4). The results of the discussion are summarized below in relation to individual EO products.

- PCA has a requirement for a range of environmental observations, many of which were not addressed by the GRIP project. For reporting purposes, the following variables need to be monitored in addition to those addressed by the GRIP project (PCA Performance Report, 2005, Figure 14):

    - Pollutants (including long- range transport of toxins);
    - Climate (including frequency of extreme events);
    - Nutrient retention (calcium, nitrogen by site);
    - Population dynamics (especially that of indicator species);
    - Trophic structure;
    - Other (mostly park- specific) issues.

- In addition, the PCA staff identified the need for other types of information required for NP management that could be derived from EO data:
    - <u>Natural resource inventories:</u> EO – derived classification products are needed by every NP to create natural resources inventories of land cover. The delineation and classification of landscape polygons derived from EO products is an ongoing requirement;
    - <u>Land cover change:</u> Quantification of temporal changes in surface features is a common ongoing need for all NPs;
    - <u>Snow/Ice/Water monitoring:</u> Spatial distribution, changes over time (especially seasonal and interannual dynamics), and quantity/thickness if available;
    - <u>Ecological processes:</u> Characterization of ecological processes through EO products, process models and/or surrogate information derived through EO;
    - <u>Visualisation products</u> of various types for communication purposes: “Whether the data source is Landsat, Ikonos, infrared colour aerial photography or other, the most common use of EO data, by far, is simply the production of visualisation products for use in Parks Canada communications or documents”.

3.5.2 Discussion

In view of the above requirements, workshop participants reviewed possibilities for expanding the collaboration between PCA and CCRS to other areas. The discussion followed a presentation by Fraser (2006) which reviewed CCRS plans for the next 3 years.

- **<u>Land use and land cover.</u>** There is ongoing need for land use and land cover products at a resolution of ~30m for NPs and the adjacent GPEs, starting with the GRIP pilot parks. Changes of interest include roads, mining, forest cutting, and the separation of natural changes from anthropogenic ones. Five- year updates are required and feasible. Basic products could be similar to those developed by the GRIP project so far, adding a layer that identifies types of disturbances. Independent ground information would help in improving product accuracy. There is no single existing product that has all the above information, and would therefore be very useful for northern parks (Nahanni, Kluane) as well as in the South (e.g., Kejimkujik);

- **Roads.** Road distribution and changes are very important information for NP management, reporting, and communications with stakeholders and the public. Some roads are never reported. The GRIP Landsat- based product does not present roads reliably. The PCA requirement is a baseline road map for NP and the GPE, with 5- year updates. Sensor resolution of ~5-10 m would be required to provide road maps and derived metrics (road development, density, buffer zones, others). The initial parks to generate the product for should be selected carefully, perhaps focusing on those that must report on EI in the next 5 years. A time series should be derived for at least one NP to assess the potential for monitoring change. Some parks (e.g., Riding Mountain NP, Prince Albert NP) have orthoimages based on air photos that could also be used as part of the time series. Some of the smaller roads may be susceptible to modeling/ prediction.
- **Annual, Canada- wide mapping of land cover changes** (by type) at a resolution of ~300m that would include all NPs and the associated GPEs in the context of their bioregions. This product would be generated in a timely way (by March of the following year) and would show all the major changes (fires, major defoliation, flooding) in one product. PCA staff considered that this product might be a transition product for reporting, serve as an effective communication tool, show the NP in context of the GPE and the bioregions, and serve as quick means of assessing changes before more detailed information becomes available. It would be very useful if accumulated over time. Animated products would be valuable for SOPHA, showing changes in Canadian landscape and how they relate to the NPs. This product would effectively complement the less frequent higher resolution (~30m) products.
- **National Forest Cover Indicator** (FCI). The National Round Table for the Environment and the Economy identified FCI (a measure of crown closure) as one of six indicators to track Canada's natural capital. FCI is an integrated measure of disturbances on forests. This product could serve as a good relative measure of habitat quality. It would be used for monitoring change and for an overview of the GPEs, not for reporting. It would also be useful for habitat modeling (section 3.4). The product should be accompanied by an interpretation guide.
- **Canada- wide snow cover information.** A snow cover product is of value to parks in the northern bioregion. The usefulness of a 1-km resolution product needs to be assessed. Daily frequency would be "really useful". The product would also be used to plan and manage fieldwork. In addition, NPs are interested in snow/ice disappearance from lakes. For southern parks, a key issue is fire danger assessment in relation to snow disappearance.
- **Ice cover.** The dynamics of lake ice and sea ice is of great interest to northern parks. Specific information required includes lake freeze-up and lake ice melt, as well as sea ice trend near marine parks and marine protected areas. Information on the ice dynamics of small tundra lakes would be useful but would require higher resolution sensors.
- **Lake temperature.** PCA is interested in lake temperature during summer months.
- **Leaf area index**. This product has an important role in productivity modeling (section 3.3).
- **Phenology** (leaf-out, maximum green, senescence). An important role in productivity modeling and in assessing ecosystem function (section 3.3).

- **Mapping land cover in the North** at a resolution of ~ 90m. This product would be of use to NPs as an early warning signal, but probably of more interest to NP partners and stakeholders.
- **Permafrost modeling.** This is of immediate interest to parks located in the discontinuous permafrost zone (Nahanni NP and others in the northern bioregion).
- **Wetland mapping.** This product is important for the PCA, especially since the existing information on wetland distribution and dynamics is poor and the existing mapping methods inadequate. Related aspects are ocean coastal wetlands and their changes (for all three oceans) due to varying sea level, and wetlands near Great Lakes (decrease in water level and coastal changes). RADARSAT 2 and hyperspectral sensors may offer special advantages regarding this need, as well for better tree species discrimination and other detailed mapping needs.
- **Information for marine parks**. Of special interest are bathymetry, water temperature, and marine ice dynamics. Marine areas range in area to >8000km^2 and have their associated marine GPEs. Information on the intertidal zone (size of intertidal area, based on multiple measurements per day) would be useful.
- **Air pollution.** Of concern to NPs are SO_2 impacts on ecosystems, and ground level ozone damage to trees. Some *in situ* monitoring is underway and more is planned. Additional measurements or monitoring tools would be very useful.
- **Fire danger.** The rate of grassland curing is a useful indicator of fire danger. PCA has established some ground plots, and would be interested in spatiotemporal information for about southern three parks.
- **Resource inventories and ecological land classification.** There is a great need to update NP inventories, but no specific plan is in place because the required level of funding is high and not presently available.

3.5.3 Actions

The following action was agreed to for this work package:

a) Further discussions are needed with park staff to identify NPs, collaborators, phasing, etc. where these products could be developed, tested and used.
   Responsible: Fraser, McLennan- bioregional ecologists Report Due: 15 March, 2006

3.6 Topic 6: Outreach

The PCA perspective on this topic was introduced by M. Whyte.

3.6.1 PCA requirements and GRIP project results to date

The Outreach session was introduced by two presentations, one on the PCA communications strategy and one demonstrating some of the existing tools and products developed in the GRIP project (Sawada, 2006, Appendix 5.4). Several products were developed using the project results (flyovers, seasonal products, others; see Sawada (2006) for details). The broad discussion then focused on the outreach strategy of the GRIP project itself, and on the potential roles of the project in the communications strategy of the PCA and of individual NPs.

3.6.2 Discussion

It was agreed that GRIP needs to communicate its work and successes both inside the PCA and to other parties, in the EO as well as ecological communities. The role of the GRIP project in the PCA strategy is critical to providing some of the building blocks (images, products, data) on which the PCA communication strategy or individual NPs can draw when developing scripts/ stories tailored to their audiences. These basic products need to be of high quality, well documented, and accessible both during the GRIP project and afterwards.

3.6.3 Actions

The following actions were agreed to for this work package:

a) Assemble 1990s marketing plans for the pilot parks.
Responsible: Zorn — *Report Due: May 31, 2006*

b) Ensure products being developed and their formats will be suitable for outreach.
Responsible: Fraser, Poitevin — *Report Due: March 31, 2007*

c) Produce a catalogue of products that are available or will be available and when
Responsible: Naughten — *Report Due: March 31, 2007*

d) Assess usefulness of a special GRIP/ NARSEC session at 2007 or 2008 CRSS conference.
Responsible: Whyte, Poitevin — *Report Due: March 31, 2006*

e) Every bioregion has a dedicated external relations staff. For next fiscal year, bioregion coordinators should involve that staff, brainstorm on how to use the GRIP products in PCA outreach.
Responsible: McLennan-bioregional ecologists — *Report Due: March 31, 2007*

f) Pursue communications on behalf of the GRIP project: newsletter contribution on the GRIP project, an article on this workshop, material for PCA intranet monitoring website, web presence, others.
Responsible: Poitevin, Fraser — *Report Due: ongoing*

g) Set up a GRIP communications task team for a 'scoping exercise' (bioregion ecologists, park managers and staff, pilot park representatives).
Responsible: Poitevin — *Report Due: ongoing*

3.7 Other matters

The following actions resulted from various thematic discussions in the workshop, and are summarized here because they apply to more than one topic.

3.7.1 Issues and Actions

Issue. An active participation of biologists from this stage to the completion of the GRIP project is considered essential to the project success – not only as advisors on the product development, but also in the evaluation and improvement of the products, and in integrating *in situ* data and knowledge in these products.

h) PARKS: Identify a biologist for every pilot park.
Responsible: McLennan *Report Due: March 31, 2007*

Issue. The documentation, preservation, and access to GRIP products and methods are key to longer term effectiveness of the project. The PCA had established an information technology policy and guidelines; the project needs to follow up in ensuring that the developed products and methods are managed properly to provide a long-term benefit to the PCA.

i) Data management: preservation, documentation, access.
Responsible: McCanny, Fraser *Report Due: March 31, 2007*

Issue. The GRIP project must report to the CSA on its progress during the FY 2005/06 by March 31, 2006.

j) Annual progress reports for GRIP relies on individual work packages for 2005/06.
Responsible: Olthof, Pouliot, Wang, Kerr, Fraser, Sawada, Poitevin
Report Due: March 18, 2006

Issue. Quality EO- derived products require ground measurements to ensure their ongoing quality and reliability, and in some cases to create the products. While the PCA staff are ideally positioned to provide such data, this could add significant additional load to their ongoing responsibilities. Therefore, the planning of *in situ* data to be provided in support of the EO products requires careful consideration.

k) What will be ground-truthing costs and responsibilities? PCA need to be able to meet these costs.
Responsible: McLennan, Fraser *Report Due: June 30, 2006*

Issue. Given that most of the prototype products have been generated; considering the originally planned products to be completed; in view of the upcoming last year for CCRS GRIP funding; and in view of the discussions at this workshop, decisions need to be made about the EO- derived products to be delivered to the NPs by the completion of the GRIP project. This could take into consideration the planned location of PCA staff at CCRS.

l) Identify final deliverables by the GRIP project.
Responsible: McLennan, Fraser *Report Due: June 1, 2006*

Issue. PCA is committed to continuing the use of methods developed in the GRIP project in its monitoring and reporting activities. To do this successfully, the transition from R&D mode to operational environment must consider tools, personnel, knowledge transfer, etc. It must therefore be planned carefully and carried out in a systematic and timely way.

m) Operationalization of GRIP products.

Responsible: McLennan, Fraser, Olthof *Report Due: June 30, 2006*

n) Knowledge transfer, training within the monitoring program.
Responsible: McLennan, Fraser *Report Due: June 30, 2006*

4. Summary and conclusions

The goal of this workshop was to review the progress of the GRIP project in light of the PCA current and anticipated needs, and to identify actions that should be taken so that the project may better meet those needs. To this end, the PCA organizers assembled a wide cross-section of park staff in terms of geographic locations, job responsibilities, and expertise. In each thematic area discussed at the workshop the PCA needs were specified; GRIP results to date reported; and the subsequent discussions in parallel breakout groups led to identifying strengths and deficiencies current products, areas for further work, and/ or needed changes in direction or emphasis. Among the six topics discussed, five dealt with the use of earth observation technology in NP monitoring, reporting, and (to a lesser degree) management:

- stressors (land cover and its changes, fragmentation);
- ecosystem processes (productivity and decomposition);
- biodiversity (species richness), and
- other EO needs.

A separate discussion on communications and outreach from the PCA and the GRIP project viewpoints also took place. A number of actions were identified, and both responsible individuals and reporting dates agreed to.

The detailed results for each thematic area are reported in section 3. of this report, and may be briefly summarized as follows:

- <u>Land cover and land cover change.</u> The present products are close to meeting the PCA requirements. Further work is needed to assess possible improvements, products need to be generated for other pilot parks, and more frequently available medium resolution products need to be incorporated into the monitoring approach.
- <u>Fragmentation.</u> The present products are close to meeting the PCA requirements. More work is needed on the selection and interpretation of the fragmentation metrics, products need to be generated for other pilot parks, and PCA biologists need to undertake park- specific interpretation of these products.
- <u>Productivity and decomposition.</u> The model- generated products are close to meeting PCA requirements. Work is needed to identify *in situ* data that should be collected for model initialization and for ensuring confidence in model outputs, and to produce and validate results for parks in various bioregions.
- <u>Species richness.</u> The GRIP products developed so far will be useful to PCA monitoring programs and for planning management interventions, but they are not expected to contribute to the PCA State- Of- the- Park reports because they do not provide actual species distributions. A number of participants have expressed interest in the modelling capability and its use for contributing to the decision-making process in NP management.

- Communications and outreach. Communications and outreach within the GRIP project are on track. Work is required to link the project activities and results into the overall PCA communications strategy, both during the project and after its completion.

In addition to the above specific areas, further work is required on planning and implementing the EO-based monitoring and product generation that will also include the acquisition and use of appropriate field observations. This process already started as part of the PCA Ecological Integrity Monitoring Program.

The CSA- sponsored GRIP project has provided the first opportunity for the PCA to incorporate EO technology into its monitoring, reporting and park management responsibilities. From the progress made so far and from the reaction of PCA workshop participants, it is evident that the GRIP- derived products will make an important and strong contribution to the PCA. The actions identified for both the PCA and CCRS participants will ensure that by the end of the GRIP project (2007-08), PCA will be in a position to integrate EO-RS into its operational/reporting needs via the national parks monitoring program.

5. Appendices

5.1 Summary of actions

Topic 1:

a) Follow up accuracy assessment (it is needed at the reporting resolution/ landscape level, for cover types within the landscape, through enough field checks, once). No one minimum accuracy specified, but would like 80% ‘power’ to detect change at the ecosystem level, every 5 years.

    Responsible: Olthof, Poitevin *Report Due: 1 April, 2006*

b) Involve park staff in labeling (including species level) and *in situ* accuracy assessment, and consider other ways of improving the suitability of the land cover product (e.g., use of the FGDC legend, its revisions, or of another legend; combination of nationally applicable and park-specific; better decision rules; use of EOSD products; value of object - based classification, etc.).

Responsible: Olthof *Report Due: 31 August, 2006*

c) Describe the post-GRIP delivery model. Must be able to complete approximately 10 parks per year.
Responsible: McLennan, Fraser *Report Due: 30 June, 2006*

d) Assess use of other data types (higher spatial resolution and higher temporal resolution) to better meet PCA needs; test crosswalk to SPOT/ other primary data source for robustness.
Responsible: Fraser *Report Due: 31 December, 2006*

e) Pursue options for improving Landsat products and adding other useful products, such as: integration of ancillary data (DEM, provincial data, soil data, fire history data, stand age maps, etc.); use radar images for wetland succession mapping; use fuel type maps for fire danger; use EO proxies of vegetation health (e.g., vegetation indices), seral stage (structure) for taiga, tundra.
Responsible: Olthof *Report Due: as appropriate*

Topic 2:

f) Finalize the selection of a parsimonious set of fragmentation metrics applicable nationally, at different resolutions/spatial extents, and to different sensors. The presented set is considered a good start.
Responsible: Pouliot, Zorn *Report Due: 30 June, 2006*

g) Explore if different products (resolution/coverage) are needed within NP and the GPE. Explore if additional FMs are needed for individual parks. Consider if further work needs to be done by the GRIP project to improve understanding of FM behaviour.
Responsible: Pouliot/Zorn *Report Due: 30 June, 2006*

h) Produce fragmentation products for the remaining pilot parks (prioritize as appropriate).
Responsible: Clouston *Report Due: January 31, 2007*

i) Subject to resources availability, follow up improvements to the products:
- Incorporate roads into the FM products;
- Incorporate landscape pattern;
- Investigate the use of higher resolution satellite data sources (radar, optical);
- Investigate other data sources with different resolution/ extent characteristics (particularly medium resolution satellite data);
- Test crosswalk to other sensors; expand the sample against which to test the FM robustness; explore options for extending time series to the past.

Responsible: Pouliot *Report Due: March 31, 2006*

j) Compile guidelines for the use of FM products across all national parks.
Responsible: McLennan *Report Due: March 31, 2008*

k) Interpret FM products (in combination with ancillary data) in pilot parks for local issues. Explore use of fragmentation products for identifying critical habitats (species at risk).

Responsible: McLennan - Bioregional ecologists Report Due: Dec 31, 2007

l) Pursue identification of ecologically based thresholds for fragmentation in the GPE (to facilitate meaningful discussion with partners about changing land use practices).
Responsible: McLennan - Bioregional ecologist Report Due: Dec 31, 2007

m) Every park will need to provide/define its Greater Park Ecosystem.
Responsible: McLennan - Bioregional ecologist Report Due: As appropriate

n) Develop a protocol for dealing with changes in technology (i.e., satellite sensors or *in situ* instruments).
Responsible: McLennan, Fraser Report Due: June 30, 2006

Topic 3:

o) Identify *in situ* observations (minimum set) that are required to ensure ongoing confidence in model outputs
Responsible: Wang, McLennan Report Due: March 31, 2007

p) Proceed with model improvements:
- Increase resolution to the species level (would be highly desirable);
- Validate age- productivity simulations;

Responsible: Wang Report Due: March 31, 2007

q) Ecosystem productivity is affected by factors currently not represented in the model (e.g. fire, insects). Determine if these should be accommodated by increasing model complexity, or by using EALCO model output as input into other models.
Responsible: Wang Report Due: As appropriate

r) Identify and evaluate options for generating NPP and decomposition products at the frequency and timeliness appropriate for national reporting (~10 parks per year), propose a realistic and cost- effective scenario to PCA with product types, formats, schedules and costs.
Responsible: McLennan, Wang Report Due: June 30, 2006

s) Define accuracy requirements for outputs.
Responsible: McLennan-Bioregional ecologists Report Due: December 31, 2006

t) Examine the feasibility and implications of collecting and providing measures of –
- Seasonal leaf phenology (most important are starting date to leaf, maximum LAI (via digital camera); also if feasible full leaf out, date of senescence), insect defoliation data;
- *In situ* initial conditions – soil carbon (kg/m^2); soil physical properties; species composition;
- Climate data: shortwave (and longwave if feasible) radiation, daily maximum and minimum temperature, daily precipitation, relative humidity, wind speed, atmospheric pressure.

Responsible: McLennan Report Due: June 30, 2006

Topic 4:

u) Complete/ revise and validate products generated to date, in collaboration with park staff.
Responsible: Kerr, McCanny *Report Due: June 30, 2006*

v) Produce products for other pilot parks, subject to available data.
Responsible: Kerr *Report Due: March 31, 2007*

w) Prepare draft protocol for *in situ* observations required for these types of models (sampling methodology,) and distribute to park staff.
Responsible: Kerr *Report Due: June 30, 2006*

x) Consider incorporating fragmentation products.
Responsible: Kerr, Zorn *Report Due: Mach 31, 2007*

y) Describe the business model for generating and using products for other parks (post-GRIP), and further examine potential use of the products for reporting.
Responsible: McLennan, Kerr *Report Due: June 30, 2006*

z) Work with park staff in the pilot parks on the interpretation and use of the products. .
Responsible: Kerr, McLennan-bioregional ecologists Report Due: ongoing

aa) Provide species observations data sets to the GRIP project for the pilot parks.
Responsible: Kerr, Lee, McCarthy, Peterson *Report Due: March 31, 2006*

bb) Provide element occurrence database for all pilot parks to Kerr.
Responsible: McCanny *Report Due: March 31, 2006*

cc) Define accuracy requirements for outputs.
Responsible: McLennan-Bioregional ecologists *Report Due: December 31, 2006*

Topic 5:

dd) Further discussions are needed with park staff to identify NPs, collaborators, phasing, etc. where these products could be developed, tested and used.
Responsible: Fraser, McLennan- bioregional ecologists *Report Due: 15 March, 2006*

Topic 6:

ee) Assemble 1990s marketing plans for the pilot parks.
Responsible: Zorn *Report Due: May 31, 2006*

ff) Ensure products being developed and their formats will be suitable for outreach.
Responsible: Fraser, Poitevin *Report Due: March 31, 2007*

gg) Produce a catalogue of products that are available or will be available and when
Responsible: Naughten *Report Due: March 31, 2007*

hh) Assess usefulness of a special GRIP/ NARSEC session at 2007 or 2008 CRSS conference.

Responsible: Whyte, Poitevin *Report Due: March 31, 2006*

ii) Every bioregion has a dedicated external relations staff. For next fiscal year, bioregion coordinators should involve that staff, brainstorm on how to use the GRIP products in PCA outreach.
Responsible: McLennan-bioregional ecologists *Report Due: March 31, 2007*

jj) Pursue communications on behalf of the GRIP project: newsletter contribution on the GRIP project, an article on this workshop, material for PCA intranet monitoring website, web presence, others.
Responsible: Poitevin, Fraser *Report Due: ongoing*

kk) Set up a GRIP communications task team for a 'scoping exercise' (bioregion ecologists, park managers and staff, pilot park representatives).
Responsible: Poitevin *Report Due: ongoing*

Other matters:

ll) Identify a biologist for every pilot park.
Responsible: McLennan *Report Due: March 31, 2007*

mm) Data management: preservation, documentation, access.
Responsible: McCanny, Fraser *Report Due: March 31, 2007*

nn) Annual progress reports for GRIP relies on individual work packages for 2005/06.
Responsible: Olthof, Pouliot, Wang, Kerr, Fraser, Sawada, Poitevin
Report Due: March 18, 2006

oo) What will be ground-truthing costs and responsibilities? PCA need to be able to meet these costs.
Responsible: McLennan, Fraser *Report Due: June 30, 2006*

pp) Identify final deliverables by the GRIP project.
Responsible: McLennan, Fraser *Report Due: June 1, 2006*

qq) Operationalization of GRIP products.
Responsible: McLennan, Fraser, Olthof *Report Due: June 30, 2006*

rr) Knowledge transfer, training within the monitoring program.
Responsible: McLennan, Fraser *Report Due: June 30, 2006*

5.2 Workshop Agenda

Time	ACTIVITY	Speakers/Leaders
8:30	Introductions – Workshop objectives	M.Wong/D. McLennan/J.Cihlar
9:00	Parks Canada's EI monitoring and Reporting program –- Getting to 2008	D.McLennan
9:20	CSA GRIP program Overview (10 min) GRIP Project Overview (10 min)	P.Briand/J.Poitevin
09:40	EO-RS CCRS General Framework & general needs	R.Fraser
10:00	**Health Break**	
	Topic 1: Ecosystem processes – Succession/ Retrogression	
10:15	Presentation: Topic introduction	D.McLennan
10:25	Presentation: La Mauricie NP Case Study (GRIP WP#2)	I.Olthof
10:45	Group Discussions & Plenary debriefing	All – Rapporteurs
12:30	**LUNCH**	
	Topic 2: Stressors – Habitat Fragmentation	
13:30	Presentation: Topic introduction	P.Zorn
13:40	Presentation: La Mauricie NP Case Study (GRIP WP#1)	D.Pouliot
14:00	Group Discussions & Plenary debriefing (and break)	All – Rapporteurs
17:00	Adjourn	
	DAY 2	
	Topic 3: Ecosystem Processes – Productivity and Decomposition (terrestrial)	
08:30	Presentation: Topic introduction	T.Naughten
08:40	Presentation: La Mauricie NP Case Study (GRIP WP#3)	S. Wang
09:00	Group Discussions & Plenary debriefing (and break)	All – Rapporteurs
	Topic 4: Biodiversity – Species Richness	
11:30	Presentation: Topic introduction	S.McCanny
11:40	Presentation: La Mauricie NP Case Study (GRIP WP#4)	J. Kerr
12:00	**LUNCH**	
13:00	Group Discussions & Plenary debriefing (and break)	All – Rapporteurs
15:15	**Health Break**	
	Topic 5: Other EO needs	
15:35	Presentation: Topic introduction	J. Quirouette
15:45	Presentation(s): EO perspective	R. Fraser
16:00	Group Discussions	All – Rapporteurs
17:00	Adjourn	

AGENDA (CON'T)

	DAY 3	
	Topic 5 cont'd: Other EO needs	
08:30	Group Discussions & Plenary debriefing (cont'd)	All – Rapporteurs
10:00	**Health Break**	
	Topic 6: Outreach	
10:15	Presentation: Topic introduction	M.White
10:30	Outreach and Visualisation products (GRIP WP#5)	M. Sawada
11:00	Group Discussions & Plenary debriefing	All – Rapporteurs
12:00	**LUNCH**	
	SUMMARY Plenary Session	
13:00	Review and discussion of actions for all Topics	J.Cihlar
15:00	Writing/ other assignments/ Assemble written materials	J. Cihlar et al.
15:30	Adjourn	

5.3 List of participants

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*5.4 List of presentations**

TITLE	Reference
Workshop Introduction	Cihlar (2006)
Parks Canada's EI monitoring and Reporting program –- Getting to 2008	McLennan (2006)
Government-Related Initiatives Program	Briand (2006)
Using Satellite Remote Sensing Technology to Monitor and Assess Ecosystem Integrity and Climate Change in Canada's National Parks	Poitevin (2006)
Framework for EO Component of PCA/CCRS GRIP Parks Project	Fraser (2006)
Ecosystem processes – Succession/ Retrogression	McLennan (2006)
Ecosystem processes : Succession / Retrogression La Mauricie National Park case study	Olthof (2006)
Earth Observation Based Landscape Pattern Assessment for Protected Areas: Results for La Mauricie National Park	Pouliot (2006)
Productivity Monitoring of Park Ecosystems	Naughten (2006)
Modeling Productivity and Decomposition with EALCO	Wang (2006)
Modeling species richness in Canadian Parks	Kerr and Desrochers (2006)
EO Needs for Monitoring Park Ecological Integrity: A CCRS Perspective	Fraser (2006)
Outreach and Visualization Products	Sawada (2006)

* These are provided in Appendix 5.7.

5.5 Charge to the breakout group discussions

Part A: Topics 1-4:

Information product issues – Questions:

A-1: What data products do park monitoring and reporting programs require for this Topic? Can we standardize on a '**core set**' that should be obtained and reported on for all national parks - nationally, by biome or by bioregion? Specify frequency of observation, spatial resolution, areal extent (if outside the park, how far?).

A-2: Does the GRIP product described at this meeting meet those requirements? How could it be improved/ changed to meet the requirements more completely – i.e. what needs to be done more/ better/ differently? Identify actions needed.

A-3: Are other EO products needed for this Topic? What additional measures would be required to account for park-specific monitoring and reporting needs? (Note this could be the current GRIP product, modified as appropriate, and/or other products). Define these and describe actions that would have to be taken (EO and ground) to develop these.

A-4: Review and consolidate actions to be taken, assign dates and names if appropriate.

Keep in mind:

- 'Data product' is one or more environmental parameters nominally presented in a digital form (images, tables, maps,..)
- Include the consideration of: what are the principle trans-boundary issues for which landscape change information is required to assess changes in park ecological integrity?
- Take into consideration needs in different parks so the resulting solutions will apply country- wide.
- Also consider/include what *in situ* data is required from park monitoring program to support the EO models.
- Identify what needs to be done (year by year if feasible and appropriate) and Responsible can take the actions and to obtain the desired results.
- In identifying actions and actors, keep in mind the goal of an operating 'system' that will support the delivery of PCA reports to be published in 2008.

Other issues (to be addressed for each Topic if time permits):

1. Can we automate all or some aspects of data/map development and delivery to minimize work effort? How will such systems work? What level of expertise will be required to deliver the data?

2. Monitoring requires repeated measures according to rigorous protocols. How do we account for technological evolution and change in EO technology, and still maintain comparable monitoring data?

3. Two new Parks Canada FTEs will flow out of the GRIP project with the key task of providing EO products in a timely manner for SOP and SOPHA reporting. These positions will be located at CCRS and funded by PCA. How can we best organize these positions to meet park operational needs?

4. How can we best deliver the technical knowledge from CCRS and the two new positions so that park monitoring staff can most effectively apply the information?

5. What needs to be done to ensure future continuity in the provision of GRIP products generated in the current project?

Part B: Topics 5-6:

Questions:

B-1: How can EO in general, and the 4 GRIP target areas in particular, contribute to the development of EI indicators for national parks?

B-2: Can we develop a coordinated approach for developing a small suite of generalized EI measures that rely on EO and other data inputs? Will this suite be sufficient for park reporting needs or will parks require substantially more park-specific EI measures based on EO data.

B-3: What are the opportunities for ongoing CSA/CCRS/PCA/UofO cooperation to meet identified and other future challenges? What is the opportunity to incorporate other kinds of EO/RS data such as high resolution satellites, active sensors such as Radar and LIDAR? What other funding sources may be available?

B-4: Responsible are our key partners to meet these needs and objectives?

5.6 List of acronyms

AVHRR	Advanced Very High Resolution Radiometer
CCRS	Canada Centre for Remote Sensing
CSA	Canadian Space Agency
DEM	Digital Elevation Model
EALCO	Ecological Assimilation of Land and Climate Observations
EI	Ecological Integrity
EO	Earth Observation
EOSD	Earth Observation for Sustainable Development
FCI	Forest Cover Indicator
FGDC	Federal Geographic Data Committee (US)
FM	Fragmentation metric
GPE	Greater Park Ecosystem
GRIP	Government- Related Initiatives Program
HVR	Haoute resolution visible
IRS	Indian Remote Sensing Satellite
LAI	Leaf area index
MODIS	Moderate Resolution Imaging Spectroradiometer
NARSEC	North American Network for Remote Sensing Park Ecosystem Condition
NP	National Park
NPP	Net Primary Productivity
PCA	Parks Canada Agency
SAR	Synthetic Aperture Radar
SOP	State Of the Park
SOPHA	State Of Protected Heritage Areas
SPOT	Systeme probatoire d’observation de la terre
TM	Thematic Mapper
UO	University of Ottawa

5.7 Workshop PowerPoint Presentations

The following pages show the PowerPoint presentations that were given by the workshop attendees.

The sequential layout of the slides on each page is as follows: